

Application No.: 09/665,366

Docket No.: EN9-99-026

AMENDMENTS TO THE CLAIMS

1. (Previously presented). A parallel joining technology method for making a multi-layer electronic structure, the method comprising:
- providing a plurality of sub-composites, wherein each said sub-composite is formed by the steps of
 - providing a layer of dielectric material having a first surface and a second surface, wherein said first surface is selected from the group consisting of a top surface and a bottom surface,
 - providing a layer of electrically conducting material on said first surface;
 - forming at least one blind via comprising a passage from said second surface through said dielectric layer to expose said layer of electrically conducting material facing said dielectric layer;
 - depositing electrically conducting metallurgical material in at least one of said blind vias wherein said electrically conducting layer is in electrical contact with said electrically conductive metallurgical material in said at least one blind via;
 - removing portions of the layer of electrically conducting material to define a pattern of circuitry;
 - stacking a plurality of said sub-composites, wherein a void is defined between adjacent sub-composites;
 - aligning said plurality of sub-composites;
 - joining said plurality of sub-composites such that the electrically conducting metallurgical material in at least one of said blind vias makes electrical contact by forming a metallurgical bond to the conductive pattern on an adjacent sub-composite;
 - flowing an un-cured resin into said voids, and
 - forming an electric insulator by curing said resin.

Application No.: 09/665,366

Docket No.: EN9-99-036

2. (Previously presented). The method according to claim 79, wherein the dielectric material is selected from the group consisting of free standing organic film, fiber reinforced resin sheet, particulate filled fluoropolymer sheet, or resin filled expanded fluoropolymer sheet.

3. (Previously presented). The method according to claim 2, wherein the free standing organic film is polyimide film.

4. (Previously presented). The method according to claim 2, wherein the free standing organic film is a liquid crystal polymer film.

5. (Previously presented). The method according to claim 2, wherein the fiber reinforced resin sheet includes at least one of glass, aramid, and liquid crystal polymer fibers and the fibers are woven or non-woven.

6. (Previously presented). The method according to claim 1, wherein a layer of electrically conducting material is provided on both the top surface and the bottom surface of the layer of dielectric material, the method further comprising removing a layer of conductive material on one of the top and bottom surface.

7. (Previously presented). The method according to claim 1, wherein the layer of electrically conducting material is patternable is solderable or can have a solderable surface layer applied.

Application No.: 09/665,366

Docket No.: EN9-99-026

8. (Previously presented). The method according to claim 1, wherein the layer of electrically conducting material comprises at least one metal.

9. (Previously presented). The method according to claim 1, wherein the layer of electrically conducting material comprises copper.

10. (Previously presented). The method according to claim 1, wherein the layer of electrically conducting material is provided by a method selected from the group consisting of lamination, physical vapor deposition, plating, and chemical vapor deposition.

11. (Previously presented). The method according to claim 10, wherein the physical vapor deposition comprises vacuum evaporation or sputtering.

12. (Previously presented). The method according to claim 10, wherein the plating comprises electroplating or electroless plating.

13. (Previously presented). The method according to claim 1, wherein the layer of dielectric material is provided by applying dielectric material to the layer of electrically conducting material.

14. (Previously presented). The method according to claim 13, wherein the electrically conducting material comprises copper.

Application No.: 09/665,366

Docket No.: EN9-99-026

15. (Previously presented). The method according to claim 13, wherein the dielectric material is applied to an electrically conductive foil by a method selected from the group consisting of screening, slot coating, curtain coating, doctor blading, roll coating, rod coating, dip coating, and spraying.

16. (Previously presented). The method according to claim 1, further comprising:
applying a layer of a protective material on the layer of electrically conducting material.

17. (Previously presented). The method according to claim 1, wherein the at least one passage through the dielectric layer is formed by laser drilling or plasma etching.

18. (Previously presented). The method according to claim 1, wherein the electrically conducting metallurgical material deposited in at least one of the at least one passage through the dielectric layer does not extend beyond an opening of the at least one passage.

19. (Previously presented). The method according to claim 1, wherein the electrically conducting metallurgical material deposited in at least one of the at least one passage through the dielectric layer does at least partially extends beyond an opening of the at least one passage.

20. (Previously presented). The method according to claim 79, wherein the electrically conducting metallurgical material is deposited in at least one of the at least one passage through the dielectric layer by plating or introducing electrically conducting paste into the at least one passage.

Application No.: 09/665,366

Docket No.: EN9-99-026

21. (Previously presented). The method according to claim 20, wherein the electrically conducting metallurgical material is deposited in at least one of the at least one passage through the dielectric layer by plating and the plating is electroplating or electroless plating.

22. (Previously presented). The method according to claim 79, wherein the electrically conducting metallurgical material is deposited in at least one of the at least one passage through the dielectric layer by introducing electrically conducting paste into the at least one passage, wherein the introduction of the electrically conducting paste comprises forcing the conducting paste into the at least one passage and curing the conducting paste.

23. (Previously presented). The method according to claim 22, wherein forcing the conducting paste into the at least one passage comprises squeegeeing the conducting paste.

24. (Previously presented). The method according to claim 1, further comprising:
providing a cap on the electrically conducting metallurgical material in the at least one passage.

25. (Previously presented). The method according to claim 24, wherein the cap comprises tin.

26. (Previously presented). The method according to claim 24, wherein the cap comprises a tin-containing alloy.

Application No.: 09/665,366

Docket No.: EN9-99-026

27. (Previously presented). The method according to claim 24, wherein the cap has a thickness of about 0.0001 inch to about 0.0004 inch.

28. (Previously presented). The method according to claim 24, wherein the cap is provided by plating an electrically conducting material on the electrically conducting material in the at least one passage.

29. (Previously presented). The method according to claim 28, wherein the plating is electroplating or electroless plating.

30. (Previously presented). The method according to claim 28, wherein the plating is maskless and self-aligning.

31. (Previously presented). The method according to claim 1, further comprising:

applying a protecting coating over the layer of electrically conducting material on the dielectric layer, wherein the protecting layer is removed prior to removing portions of the layer of electrically conducting material to define a pattern of circuitry.

32. (Previously presented). The method according to claim 1, wherein removing portions of the layer of electrically conducting material to define a pattern of circuitry comprises depositing a layer of photoresist on the layer of electrically conducting material, exposing the photoresist, developing the photoresist to form a mask for selectively removing portions of the layer of electrically conducting material, and removing remaining portions of the photoresist.

Application No.: 09/665,366

Docket No.: EN9-99-026

33. (Previously presented). The method according to claim 1, further comprising:

treating the layer of dielectric material and the pattern of circuitry with an immersion ~~in~~
plating solution.

34. (Previously presented). The method according to claim 1, further comprising:

treating the layer of dielectric material and the pattern of circuitry in a fluorine-containing
plasma.

35. (Previously presented). The method according to claim 1, wherein the structures are aligned
with at least one of aligning pins and aligning marks.

36. (Previously presented). The method according to claim 1, wherein the structures are stacked
one-by-one and each time another structure is added to the stack it is soldered to a structure in
the stack.

37. (Previously presented). The method according to claim 1, wherein forming a metallurgical
bond comprises heating the structures to a temperature above a melting point of at least one of
the constituent of, or the cap deposited on, the electrically conducting metallurgical material
deposited in the at least one passage in the dielectric layer.

38. (Previously presented). The method according to claim 37, wherein joining the structures
further comprises applying pressure to the stack from above and below.

Application No.: 09/665,366

Docket No.: EN9-99-026

39. (Previously presented). The method according to claim 37, wherein the joining is carried out in an atmosphere that is inert under the conditions that the joining is carried out under.

40. (Previously presented). The method according to claim 39, wherein the joining is carried out in a nitrogen atmosphere.

41. (Previously presented). The method according to claim 37, wherein the joining is carried out under a vacuum.

42. (Previously presented). The method according to claim 1, wherein the spaces between the structures are filled with a low viscosity, thermosetting resin.

43. (Previously presented). The method according to claim 42, wherein filling the spaces comprises arranging a gas impermeable flexible covering about the plurality of structures, sealing a periphery of the plurality of structures in the vicinity a top and a bottom surface of the plurality of structures, and introducing the resin into the covering.

44. (Previously presented). The method according to claim 43, wherein after introduction the resin is cured.

45. (Previously presented). The method according to claim 16, wherein the protective material is photoresist.

Application No.: 09/665,366

Docket No.: EN9-99-026

46 - 67. (canceled).

68. (Previously presented). A parallel joining technology method for making a multi-layer electronic interconnect structure, the method comprising:

providing a layer of dielectric material bonded to a layer of electrically conductive material, the layer of dielectric material having substantially uniform thickness;

forming at least one passage through the layer of dielectric material to expose a portion of the layer of electrically conductive material;

depositing electrically conducting metallurgical material in at least one of the at least one passage through the layer of dielectric material, such that the electrically conducting metallurgical material in the at least one passage is in electrical contact with the layer of electrically conducting material bonded to the layer of dielectric material and extends beyond a surface of the layer of dielectric material;

removing portions of the layer of electrically conducting material to define a pattern of circuit conductors, such that at least one of the circuit conductors remains electrically connected to the electrically conductive metallurgical material deposited in that at least one of the at least one passage through the layer of dielectric material;

stacking and aligning a plurality of structures comprising the layer of dielectric material with circuit conductors disposed thereon and conductively filled passages therethrough such that one of the following conditions exists:

a) at least one conductively filled passage in a structure contacts at least one circuit conductor on the conductive layer of an adjacent structure,

Application No.: 09/665,366

Docket No.: EN9-99-026

b) at least one circuit conductor on the conductive layer of a structure contacts at least one conductively filled passage in an adjacent structure, or

c) at least one conductively filled passage in a structure contacts at least one conductively filled passage in an adjacent structure;

electrically and mechanically joining the electrically conductive metallurgical material filling one of the at least one passage that is aligned with an electrically conductive feature on an adjacent structure to the adjacent structure conductive features;

filling the space between adjacent structures with an uncured resin; and
forming an electrical insulator by curing said resin.

69. (Previously presented). The method according to claim 68, wherein the electrically insulating material used to fill spaces between the adjacent structures comprises a liquid which is transformed into a solid subsequent to filling the spaces.

70. (Previously presented). The method according to claim 69, wherein the transformable insulating material is an organic resin.

71. (Previously presented). The method according to claim 70, wherein the organic resin includes at least one member selected from the group consisting of epoxy, acrylic, cyanate ester, urethane, polyester, bismaleimide triazine, silicone, and mixtures or copolymers thereof.

Application No.: 09/665,366

Docket No.: EN9-99-0X

72. (Previously presented). The method according to claim 70, wherein the transformable electrically insulating material comprises at least one inorganic particulate filler in an amount up to about 60 percent by volume.

73. (Previously presented). The method according to claim 70, wherein the transformable electrically insulating material is converted to a solid by at least one means selected from the group consisting of chemical polymerization and cross linking reactions.

74. (Previously presented). The method according to claim 68, wherein filling spaces between adjacent structures comprises introducing a liquid electrically insulating material into the spaces and allowing capillary forces to transport the liquid from a point of introduction throughout the spaces.

75. (Previously presented). The method according to claim 74, wherein the liquid electrically insulating material is introduced at least one point around peripheries of the layers of dielectric material.

76. (Previously presented). The method according to claim 74, wherein the liquid electrically insulating material is introduced at a pressure greater than atmospheric pressure in order to provide a larger driving force for material transport than provided by capillary forces alone.

Application No.: 09/665,366

Docket No.: EN9-99-026

77. (Previously presented). The method according to claim 74, wherein a vacuum is created and maintained in spaces between the adjacent structures during a time when the liquid electrically insulating material is being introduced.

78. (Previously presented). The method according to claim 77, further comprising:

- arranging a gas impermeable flexible covering about the plurality of structures;
- sealing the flexible covering to the plurality of structures about top and bottom peripheries of the structures;
- evacuating the atmosphere from within the flexible covering;
- introducing a liquid electrically insulating material into the evacuated covering in the vicinity of at least one edge of the plurality of structures;
- allowing the liquid electrically insulating material to fill the spaces between structures;
- transforming the liquid electrically insulating material into a solid; and
- removing the gas impermeable covering.

79. (Previously presented). The method of claim 1 wherein said electrically conducting metallurgical material comprises a material selected from the group consisting of a plated metal, a plated alloy, a conductive paste having metal particles, at least a portion of which are fusible, present in a volume fraction above a percolation threshold, a conductive paste having fusible metal particles, and a conductive paste having metal particles coated with a fusible metal coating.

80. (Canceled).